

# ABSTRACT

Composite media having simultaneous negative effective permittivity and permeability over a common band of frequencies. A composite media of the invention combines media, which are either themselves separately composite or continuous media, having a negative permittivity and a negative permeability over a common frequency band. Various forms of separate composite and continuous media may be relied upon in the invention. A preferred composite media includes a periodic array of conducting elements that can behave as an effective medium for electromagnetic scattering when the wavelength is much longer than both the element dimension and lattice spacing. The composite media has an effective permittivity  $\epsilon_{\text{eff}}(\omega)$  and permeability  $\mu_{\text{eff}}(\omega)$  which are simultaneously negative over a common set of frequencies. Either one or both of the negative permeability and negative permittivity media used in the invention may be modifiable via external or internal stimulus. Additionally, the medium or a portion thereof may contain other media that have medium electromagnetic parameters that can be modulated. The frequency position, bandwidth, and other properties of the left-handed propagation band can then be altered, for example, by an applied field or other stimulus. Another possibility is the use of a substrate which responds to external or internal stimulus.